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(54) **Writing information in a display device.**

(57) Information is written in a display device (10) wherein the information written remains thereon for viewing. The display device is of the type where the brightness of the information on the display surface increases with the length of time during which it is written which defines the writing time of the information. The brightness reaches a maximum level after the writing time exceeds a predetermined time period defining a saturation time. The information is written on the display surface of such type of device for a writing time which is less than the saturation time. If so desired, the same information can be written repeatedly at the same address to increase the brightness of the information to the desired level. Alternatively, information can be written once for a selected writing time to achieve any level of brightness desired. In such manner a grey scale of brightness for displaying images may be implemented (fig. 1).

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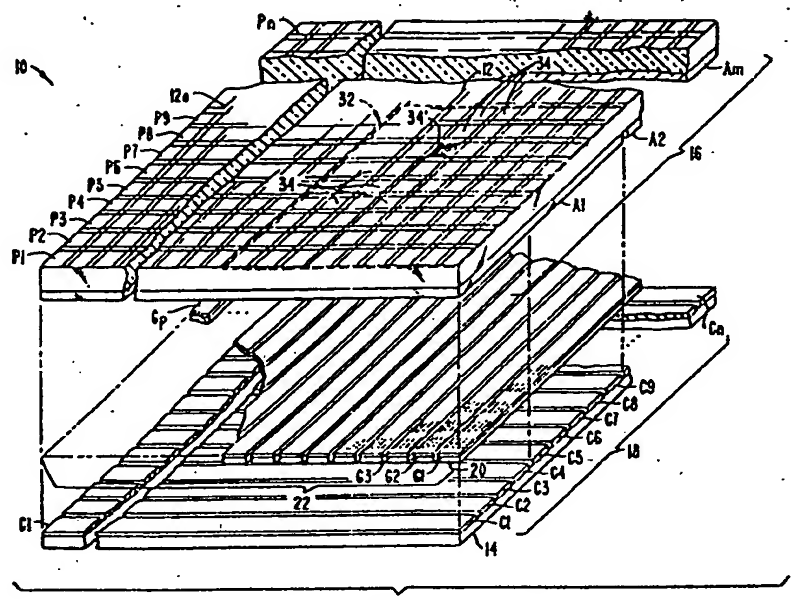

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FIG._1.

WRITING INFORMATION IN A DISPLAY DEVICE

This invention relates in general to the addressing of image displays and in particular to the addressing of image displays that are capable of "remembering" the images written.

Two types of devices have been used for displaying images. The first type has very short addressing times, typically of the order of microseconds. The images written, however, decay rapidly and the device is said to have no memory capability. A common display device of this type is the cathode ray tube (CRT). To write an image at the proper address on the CRT screen in a process known as addressing, an electron beam is directed at such address. The CRT screen contains a fluorescent material, usually phosphor, which fluoresces when struck by an electron beam. Once the striking stops, however, the brightness of the image thus formed decays rapidly. Thus, to maintain an image on such a device the image has to be continuously refreshed.

A second type of frequently used image displays has long addressing times, typically of the order of milliseconds, but has memory capability. In this type of display, the image written remains indefinitely after addressing stops so that the image need not be refreshed. One example of the second type of image displays is the electrophoretic image display (EPID). An EPID device typically comprises charged particles suspended in an organic fluid such as xylene. The suspension is

contained between a front, a back and side panels, the outside surface of the front panel serving as the display surface.

The EPID suspension fluid is normally dyed to become opaque for masking the particles which are away from the display surface. The suspension is placed between two sets of electrodes, one set near the back panel and the other set near the front panel. By applying appropriate voltages across selected individual electrodes of the two sets of electrodes the charged particles are caused to move from the back panel towards the front panel. When the particles reach the front panel, they are not masked by the suspension fluid. They can then be seen at locations on the display surface determined by the locations of the particular electrodes selected for application of voltages. In such manner, the application of voltages to selected electrodes generates images on the display surface. The colors of the particles and of the dye in the suspension fluid are chosen so that the images created will have good brightness and contrast. The EPID type device is disclosed in U.S. Patent Nos. 3,668,106; 3,892,563; 4,041,481; 4,093,534 and 4,203,106. The above six patents are incorporated herein by reference as background for the technology and display techniques for the EPID type device.

In the CRT, addressing is accomplished by moving the electron beam so that it strikes a display surface at the location where the desired image is to be displayed. In the EPID type device addressing is accomplished by applying the appropriate voltages across the electrodes that intersect at points corresponding to the desired address of the image on the display surface.

Because of the limitations in two dimensional addressing (X-Y addressing) using electrodes, the addressing of images in EPID devices is performed sequentially. In other words, the images to be written on a section of the screen covered by a number of pixel lines are written one pixel line at a time.

For the CRT type of image displays with very short addressing times (microseconds), the sequential addressing of a large amount of information requires little time so that it causes little inconvenience to the viewer. With display devices requiring long addressing times such as in EPID type displays this is not the case. In the EPID type device long addressing times (of the order of 10 milliseconds) are required in order to move enough charged particles from the back panel of the device to the front panel to create images of full brightness and contrast. A display surface may contain 100 or more pixel lines. If a large amount of information is to be written all the pixel lines must be addressed. In conventional addressing methods, each pixel line is written sequentially to the full brightness and contrast before the next pixel line is written so that 1 second is required to write a full screen of text or other images on an EPID device. The lengthy writing time becomes particularly troublesome when a viewer desires to only skim or scroll a text such as instances at which the viewer wishes to find a particular page of a long document. It is therefore desirable to provide a method for writing images which allows a viewer to scroll a long document. It is also desirable to provide a method which allows more flexibility than the conventional method of addressing and writing images.

According to the invention there is provided a method for writing information in a display device, wherein information written on the display surface of the device remains thereon for viewing after addressing stops, wherein the brightness of the information on the display surface increases with the length of time during which the information is written, wherein said length of time defines the writing time of the information and wherein the brightness reaches a maximum level after the writing time exceeds a predetermined time period defining a saturation time, said method comprising writing a first information on the display surface for a first writing time less than the saturation time.

If so desired, the same information can be written repeatedly at the same address to increase the brightness of the informatin to the desired level. Alternatively, information can be written once for a selected writing time to achieve any level of brightness desired. In such manner a grey scale of brightness for displaying images may be implemented.

The invention will be better understood from the following description, given by way of example and with reference to Fig.1 of the accompanying drawings, which is an exploded perspective view of an EPID cell partially cut away to illustrate a preferred embodiment of this invention.

As shown in Fig.1, EPID cell 10 comprises a front panel 12 and a back panel 14. Substantially parallel strips of an electrically conductive material are deposited on the inside surface of the front panel 12 to serve as a set of anodes 16 (A1, A2, ..., Am), m being a positive integer. Substantially parallel strips 18 (C1, C1, ..., Cn), n being a positive integer, of a conductive

material are deposited on the inside surface of back panel 14 to serve as a set of cathodes. Each strip anode is electrically isolated from adjacent strip anodes and each strip cathode is electrically isolated from adjacent strip cathodes. On top of cathodes 18 is deposited a layer of electrically insulating material 20. On top of layer 20 are deposited p substantially parallel strips 22 (G1, G2, ..., Gp) of conductive material to serve as the grid electrodes, p being a positive integer. Adjacent grid electrodes are also electrically isolated from each other.

The portions of insulating layer 20 exposed in between the grid electrodes are etched away in a conventional manner to expose small sections of the cathodes between the columns of grid electrodes. When cell 10 is viewed from the front through front panel 12, the grid electrodes 22 overlap cathodes 18 in square or rectangular sections. Dalisa in U.S. Patent No. 4,203,106 discloses an EPID cell somewhat similar to that described above.

The electrophoretic suspension is enclosed between the front panel, back panel and side panels (not shown) of the cell. When voltages of the appropriate waveforms are applied to the anodes, grids and cathodes, EPID cell 10 is made to display desirable images. In a preferred embodiment the number of m strips of anodes correspond to m lines for displaying m lines of characters of text or other images through the front panel 12. To display a character such as a letter of the alphabet, the display screen must be addressed so that pigment particles will appear only in some parts and not in other parts of the area of the screen for displaying the character so that the contrast formed between the parts at

which there are particles and the parts at which there are no particles will display the desired character. Thus each character line must be further divided into smaller units known as pixels for addressing in order to display characters. The addressing of pixels is explained in more detail below. The outside surface of front panel 12 is the display surface through which images are viewed. In the preferred embodiment there may be 27 strip anodes for displaying 27 lines of characters or images at the display surface. There are many more strip cathodes and strip grids than strip anodes. In the preferred embodiment there are over 200 cathodes and grids.

The square or rectangular section on the display surface corresponding to the area where a cathode and a grid intersect is called a pixel and each cathode Ci defines a pixel line Pi, i = 1, 2, ..., n. Each anode, thus, matches a number of cathodes and the same number of pixel lines. The anode A1 for example matches cathodes C1-C9 and pixel lines P1-P9 as shown in Fig. 1. The area 32 on the display surface corresponding to a section of anode A1 may correspond to the area suitable for displaying one image or character. As shown in Fig. 1 area 32 contains 81 smaller rectangular or square sections each corresponding to a pixel. Pixel 34' for example may correspond to the overlap between cathode C7 and grid G6 as shown in the Fig.1. By applying the appropriate voltages to the selected anodes, grids and cathodes, the appropriate images may be displayed in each individual pixel such as pixels 34 across the entire display surface 12a. Dalisa et al, in U.S. Patent No. 4,203,106, describe certain voltages and the technique for applying such voltages to the electrodes for displaying desired images in each individual pixel.

The process of writing images on the display surface 12a can now be described. Typically such images are written from one side of the surface to the other, such as from top to bottom. Thus, the appropriate voltages may be applied to anode A1, cathode C1 and grids G1-Gp to write the top pixel line P1 of display surface 12a. Then the appropriate voltages are applied to cathode C2 and all the grids to write the next to the top line P2. This process is then repeated until we reach the bottom of the display surface at the bottom line Pn. Alternatively, the process may instead begin with cathode Cn so that the images are written from the bottom line of the display surface Pn towards the top line P1.

The conventional addressing method in EPID cells is to apply the appropriate voltages for a time period sufficient to bring enough particles in the suspension towards each pixel line, such as line P1, so that the images written thereby appear in full brightness and contrast before the next line is written. After the first line P1 of images is written the appropriate voltages are then applied to cathode C2, the grids and anode A1 for writing the second line of images again to the full brightness and contrast. In order to write a pixel line to the full brightness and contrast a time period on the order of 10 milliseconds is required. Thus, if 200 pixel lines are to be written, it will require 2 seconds to completely write all the pixel lines P1 to P200.

For many viewing purposes, however, full brightness and contrast may not be required. Thus, when EPID cell 10 is used to display textual material in word processing, the viewer may only wish to find the appropriate paragraph or page in a long document. Thus

the viewer is interested not in reading each individual word on the display surface but only in the general content of images on a large number of pixel lines. For such purpose displaying images with less brightness and contrast than the maximum may be adequate. Fainter but adequate images are achieved by addressing each pixel line P1-Pn for a time period less than the saturation time period. If the viewer wishes to read each individual word of the display so that greater brightness and contrast are desirable the images already written on the pixel lines can simply be written again at the same address to the desired brightness and contrast. The process of writing an image already written at the same address is referred to below as "overwriting." Alternatively, if the viewer wishes to discard the images displayed to display another screen full of information the viewer will have spent less time in the process. The different applications and advantages of the invention are explained below.

Using the above-described method, either a screen full of information or a single character line such as the character line corresponding to anode A1 can be written to the desired brightness and contrast. Each individual pixel line in such character line can be multiply written. Assume for the purpose of discussion that 10 milliseconds is the time required to achieve full brightness and contrast, that is, the saturation time. Each individual cathode among cathodes C1-C9 corresponding to the character line is first written or addressed for a time period less than 10 milliseconds to write the pixel lines P1-P9. This will cause the 9 pixel lines to display a faint image. Then the same pixel lines P1-P9 are addressed a second time for a time period less than

the saturation time to increase the brightness and contrast of the images already written. Thus, to the viewer, the entire character line corresponding to anode A1 will be brought to full brightness and contrast uniformly. In contrast, if the prior art method of writing is used, one side of the character line will be written first before the remaining part of the line. For example, pixel line P1 may be written to full brightness and contrast and then the next pixel line P2 and then lines P3-P9.

Similarly the entire screen may be written for a writing time period less than the saturation time and then overwritten to bring the entire screen uniformly to increased brightness and contrast. Bringing the image to be displayed to full brightness and contrast more uniformly by overwriting may cause less distraction to the viewer than the conventional method.

By choosing to write for time periods less than the saturation time, it is
possible for the viewer to scroll information in a faster and smoother manner than the conventional method. During scrolling each individual character line is shifted towards the top of the display surface by one character line at a time. This means that each individual character line has to be erased and rewritten so that the entire display surface must simply be erased and rewritten. If each individual line is written to the full brightness before the next pixel line is written a full 1 or 2 seconds may be required to write the entire display surface. Thus, the viewer will have to wait 1 or 2 seconds for the character lines to be shifted by one character line. For scrolling purposes the viewer does not need to see each character line in its full brightness

before deciding to continue scrolling. By reducing the addressing time from 10 milliseconds to say 2 milliseconds, each screenful of information will have been displayed in 0.2 or 0.4 seconds so that the viewer can decide whether to continue scrolling after only 0.2 or 0.4 seconds. It is found that addressing times on the order of one-fifth of the saturation time may be adequate for the purpose of scrolling.

Faster and smoother image changes on the screen other than scrolling can also be achieved including movement of windows or graphic animation. To accomplish such change the character lines on which the changes occur are simply erased and rewritten for time periods less than the saturation time to speed up the addressing process. For many of such viewing purposes full brightness and contrast are again not necessary.

The description above relates to application to an EPID cell with a number of strip anodes, such as 27 strip anodes. It will be understood that the invention may be applied to an EPID cell which includes a different number of strip anodes, or even only one anode (that is, m in Am may be any positive integer, including 1). The description above has been given in the context of an addressing scheme where the consecutively written lines on the display, or pixel lines, correspond to strip cathode lines; that is, Pi corresponds to Ci, i=1,..., n. It will be understood that the technique described above is equally applicable in the context of an addressing scheme where the pixel lines correspond to the strip grid lines instead; that is, Pi corresponds to Gi, i=1,..., p. In such addressing scheme and where the grid lines are vertical as shown in Fig. 1, it may be desirable to rotate the EPID cell about an axis perpendicular to surface 12

for 90 degrees so that the grid lines and hence the pixel lines will again be horizontal for the convenience of viewers.

It is also possible to display images having different degrees of brightness and contrast. To increase the brightness of a particular pixel it is simply overwritten repeatedly. In one implementation of the method, during each of a number of passes in addressing, each individual pixel addressed is written for substantially the same time period. To increase the brightness of a particular pixel such pixel is simply overwritten repeatedly. For other pixels where less brightness is adequate they are either not overwritten or overwritten for fewer passes. Thus, if an image is written with n passes of equal duration, there can be n + 1 shades between light and dark, ranging from no pass to n passes. In an alternative implementation of the method, all the pixels to be written are written only once in a single pass, but the writing time of each pixel may differ. The unequal durations of the addressing passes may be chosen, for example, from a set of different writing times, so that the brightness of the information displayed is selectable from up to n+1 levels for n passes. The set of different writing times may be selected from multiples of a base time period such as 1 millisecond. The set of writing times may conveniently be a binary progression of addressing times (1, 2, 4, 8, 16, ... 2^n microseconds). The two schemes can be combined to achieve up to 2^n grey levels. In the combined scheme, selected pixels may be overwritten repeatedly and for unequal durations.

Some of the different modes described above can be combined. Thus, after the viewer has scrolled a

document to the point that the viewer wants to stop scrolling and read the information more carefully the erasing and rewriting of the full screen of images stop and the display surface is simply multiply overwritten repeatedly so that the brightness and contrast increase uniformly to the maximum.

In the EPID type device, addressing times of the order of one or two milliseconds have been found to achieve sufficient brightness for purposes such as scrolling. If an image is overwritten repeatedly, it is found that the brightness achieved bears a generally linear relationship to the total time during which it is written. Thus, two strikes of one millisecond each may be equivalent to one strike for two milliseconds. It will be understood, however, that the invention as defined in the appended claims is not limited to EPID type devices, or devices where the brightness is related linearly with the addressing time.

CLAIMS:

1. A method for writing information in a display device, wherein information written on the display surface of the device remains thereon for viewing after addressing stops, wherein the brightness of the information on the display surface increases with the length of time during which the information is written, wherein said length of time defines the writing time of the information and wherein the brightness reaches a maximum level after the writing time exceeds a predetermined time period defining a saturation time, said method comprising writing a first information on the display surface for a first writing time less than the saturation time.

2. A method as claimed in claim 1, further comprising writing second information on the display surface for a second writing time.

3. A method as claimed in claim 2, wherein the second information is substantially the same as the first information and has substantially the same address as the first information so that writing of the second information increases the brightness of the first information on the display surface.

4. A method as claimed in claim 2, wherein the second information is different from the first information.

5. A method as claimed in claim 4, wherein the second information does not overlap the first information, so that both the first and second information are displayed.

6. A method as claimed in claim 5, wherein the first and second writing times are selected so that each of the first and second information is displayed with the desired brightness.

7. A method as claimed in claim 5 or 6, further comprising overwriting the first or the second information to increase the brightness of the first or the second information.

8. A method as claimed in claim 4, further comprising the step of erasing at least part of the first information before the second information is written, and wherein the first and second writing times are selected so that the first and second information can be skimmed or scrolled quickly and so that the brightness of the first and second information are adequate for skimming or scrolling.

9. A method as claimed in claim 2, further comprising the steps of sequentially writing up to n information, n being an integer, where the i^{th} information is written for the i^{th} writing time, and wherein the n writing times are selected from a set of different writing times, so that the brightness of the information displayed is selectable from up to n+1 levels.

10. A method as claimed in claim 9, wherein said set of different writing times is formed from multiples of a predetermined base time period.

11. A method as claimed in claim 10, wherein said set of different writing times is formed from multiples of 2 of the predetermined base time period.

12. A method as claimed in claim 2, further comprising the steps of sequentially writing up to n information, n being an integer, wherein at least some of the n information are substantially the same and have substantially the same address and wherein each of the n information is written for substantially the same writing time, so that a selected information may be written repeatedly for up to n times and so that the brightness of information displayed is selected from n + 1 levels, wherein the $(i+1)^{th}$ level is selected by repeatedly writing such information for i times.

13. A method as claimed in claim 2, further comprising the steps of sequentially writing up to n information, n being an integer, wherein at least some of the n information are substantially the same and have substantially the same address and wherein at least two of the n information are written for unequal writing times, so that a selected information may be written repeatedly for up to n times and so that the brightness of information displayed is selected from 2^n levels.

14. A method as claimed in any one of claims 1 to 5, wherein the first and second writing times are of the order of 2 milli-seconds.

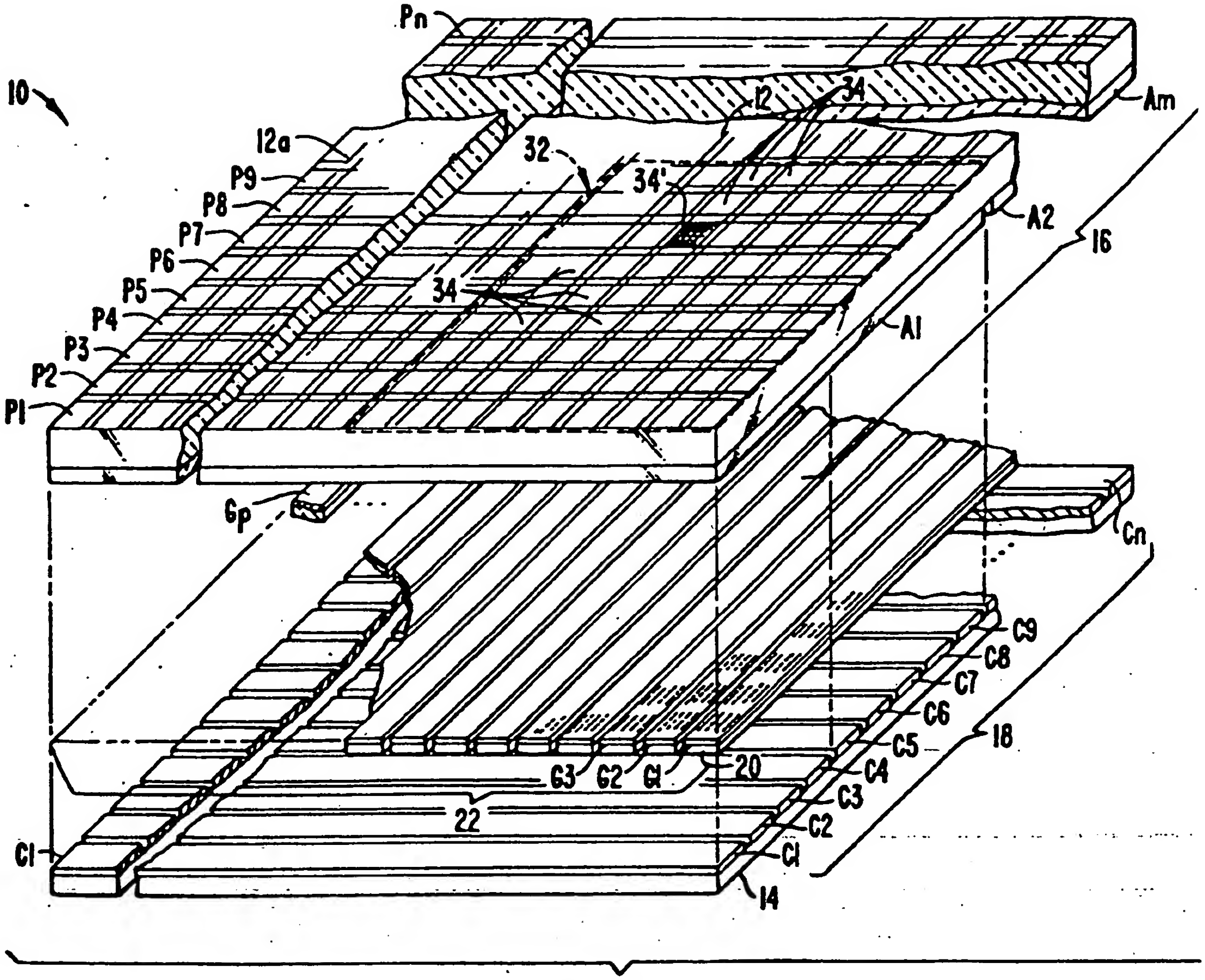

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FIG._1.